Clark Leonard Hull
(1884-1952)

Chapter 6

1

Clark Leonard Hull

1. Born Mar. 20, 1884 Susquehanna, Pennsylvania.
2. Belonged to poor household. Contracted polio at 24.
3. Completed his PhD (1918) from University of Wisconsin. Studied Aptitudes and hypnosis.

(1884-1952)

2

Clark Leonard Hull

4. Provoked by Pavlov to study conditioning.
5. Taught at Wisconsin and then went to Yale.
6. Wrote *Principles of Behavior (1943),* and *A Behavior System (1952).*
7. Became the most cited psychologist in the 40s and 50s. Died in 1952.

(1884-1952)

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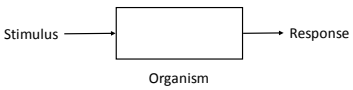
SHOUT
SHARE
IT

Watson's Behaviorism

1. Watson's behaviorism radically denounces mind and consciousness and focuses on overt measurable behavior.
2. For Watson, the organism is empty and brain physiology merely connects stimulus with response.



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Disagreement with Watson

1. Hull believed that Watson's rejection of unobservable events inside the organism (body and brain) was unscientific.
2. Hull argued that physicists and chemists make inferences about things that they have not actually seen or observed, e.g., gravity, forces, atoms, molecules etc., but such phenomena exist.

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Mediating Events

1. Hull proposed that since we cannot observe the mediating events inside the organism, it does not mean that they do not exist.
2. In order to study these mediating events we need to operationally define them. In other words operational definitions are those that can quantify these events.

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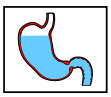
Hunger: Mediating Event

1. Hunger can be defined as feeling of emptiness or the sensation of "pangs" in the stomach. However this definition is very subjective and difficult to measure.
2. An operational definition of hunger is, number of hours of food deprivation. This definition of hunger is quantifiable.

Hunger = 8 hrs of food deprivation



Organism

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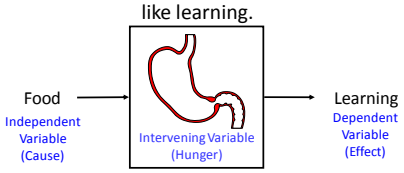
Intervening Variable

Operationally defined mediating events, like hunger are intervening variables that reside in the organism and are caused by factors like food deprivation, thus they can effect behavioral change like learning.



Organism

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Agreement with Watson

1. Hull totally agrees with Watson in stating that these intervening variables are not mind or mental events.
2. Thus (mental) feeling of "hungriness" was not important to Hull, but hunger as food deprivation was, because it could be measured and tested to explain behavior.

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Neobehaviorism

Hull thus evolved a new brand of behaviorism (neobehaviorism) which uses intervening variables as hypothesized physiological processes, to explain behavior.

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Hypothetico-Deductive System

Hull developed a dynamic system that framed hypotheses and refined them to support and modify learning theory.

1. Reviewed research on learning.
2. Summarized all those findings.
3. Developed hypotheses from those summarized findings. Hull formulated 16 (1943) postulates (18 postulates, 1951) and many theorems to explain his learning theory.

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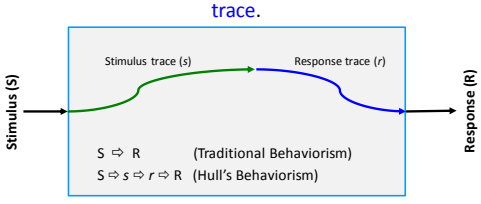
Postulate 1: Stimulus Trace

External stimulation triggers a sensory impulse that continues for a few seconds after the stimulating event has terminated. This impulse is the stimulus trace.



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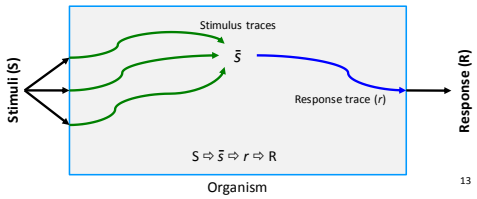
Postulate 2: Impulses Interact

Each organism is bombarded by many stimuli and thus many sensory traces are generated. These traces interact with one another, and represent complexity of stimulation.



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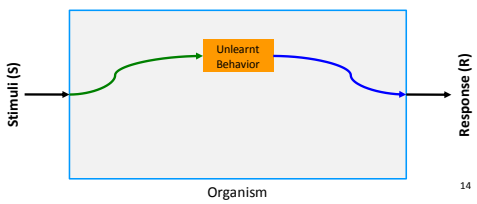
Postulate 3: Unlearnt Behavior

Organisms are born with hierarchy of unlearnt responses. Unlearnt behaviors are triggered first when the need arises. If these behaviors fail organism *learns* new behaviors to reduce the need.



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Postulate 3: Unlearnt Behavior

Need	Hierarchy of Behaviors	Behavior
Cold	Shivering	
	Crouching	
	Moving/running	Unlearnt
	Eating/drinking	
	Urinating/defecating	
	Wearing clothes	Learnt
	Turning heat on	

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Postulate 4: Drive Reduction

1. If a stimulus triggers a response which leads to satisfaction of a biological need, the association between stimulus and response is strengthened (Thorndike, 1925).
2. Though Hull agrees with Thorndike that reinforcement strengthens the stimulus-response bond; but Hull defines reinforcement as drive reduction as opposed to "satisfying state of affairs".

Stimulus → Response → Reinforcement reduces the need

Bond Strengthened

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Postulate 4: Drive Reduction

As the association between stimulus and the response strengthens, Hull says that the "habit" of giving that response to that stimulus increases.

This habit strength is represented as:

$_{S}H_{R} = 1 - 10^{-0.0305N}$ (or $_{S}H_{R} = 1 - 1/10^{0.0305N}$)

Where N is the number of successive reinforcements strengthening stimulus and response.

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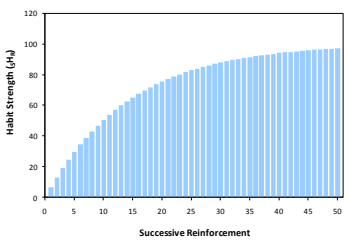
Postulate 4: Drive Reduction

Increase in successive reinforcements leads to increase in habit strength.



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Postulate 5: Stimulus Generalization

Similar stimuli will evoke the same response or habit. Prior experience will affect current learning. Hull called it, Generalized Habit Strength ($_S\overline{H}_R$).

This is similar to Pavlov's stimulus generalization, and to Thorndike's identical elements theory, where identical elements in stimuli across situations evoke the same or similar response.

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Postulate 6: Drive Stimuli

A biological deficit produces a drive *(D)* which is associated with drive stimuli.

Drive	Internal Stimulus	External Stimulus
Hunger	Pangs	Smell of food
Thirst	Parched throat	Sight of water

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Postulate 7: Reaction Potential

The probability of a learned response occurring at a particular moment is called reaction potential ($_SE_R$), and is the product of habit strength and drive. If habit strength or drive equals zero, reaction potential equals zero.

$$_SE_R = {}_SH_R \times D$$

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Postulate 8: Reactive Inhibition

Responding causes fatigue, and fatigue eventually inhibits responding. This is called Reactive Inhibition (I_R). Fatigue is a negative drive state. Makes the animal not to respond.

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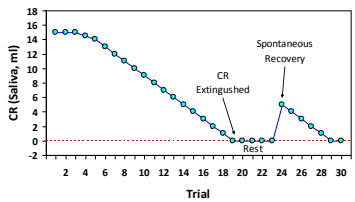
Rest from Fatigue

Extinction of a response not only results from lack of reinforcement but also from fatigue. When rest ameliorates fatigue, extinguished response spontaneously recovers.



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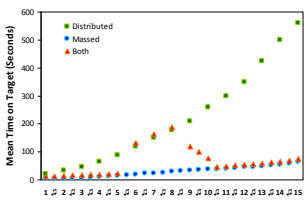
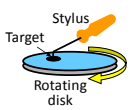
Reminiscence Effect

Mass practice on a motor task (rotating disk) increases fatigue, and thus results in poorer performance compared to distributed practice.





(Kimble and Garmezy, 1968)

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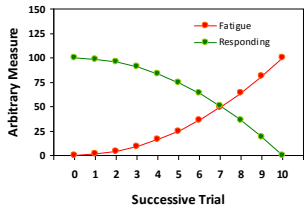
Postulate 9: Conditioned Inhibition

Fatigue conditions the animal not to respond. Learning not to respond avoids fatigue and is called conditioned inhibition (${}_SI_R$).



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Effective Reaction Potential

Effective reaction potential is thus generated by habit strength (${}_SH_R$), Drive (D), reactive inhibition (I_R) and conditioned inhibition (${}_SI_R$). Where product of ${}_SH_R$ and D (increasing ${}_SE_R$) and the sum of I_R and ${}_SI_R$ (decreasing ${}_SE_R$) need to be subtracted from each other to generate an effective reaction potential.

$$ {}_S\bar{E}_R = \overbrace{{}_SH_R \times D}^{\uparrow {}_SE_R} - \underbrace{(I_R + {}_SI_R)}_{\downarrow {}_SE_R} $$

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Postulate 10: Oscillation Effect

Factors that inhibit learnt responses change from moment to moment. This inhibitory potentiality is called the oscillation effect (${}_SO_R$), and is a wild card in Hull's theory.

The ${}_SO_R$ must be subtracted from effective reaction potential to calculate momentary effective reaction potential (${}_S\dot{\bar{E}}_R$).

$$ {}_S\dot{\bar{E}}_R = [{}_SH_R \times D - (I_R + {}_SI_R)] - {}_SO_R $$

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Postulate 11: Reaction Threshold

The learned response will only be emitted if ${}_S\dot{\overline{E}}_R$ is greater than reaction threshold ${}_SL_R$.

Postulate 12: Response Occurrence

The probability that a learned response will occur as a combined function of if ${}_S\dot{\overline{E}}_R$, ${}_SO_R$, and ${}_SL_R$.

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Postulate 13: Response Latency

The greater the value momentary effective reaction potential ${}_S\dot{\overline{E}}_R$ the shorter the latency (time) ${}_St_R$ between S and R.

Postulate 14: Resistance to Extinction

The value ${}_S\dot{\overline{E}}_R$ will determine resistance to extinction. The greater its value the greater the resistance to extinction.

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Postulate 15: Response Amplitude

Some learnt responses occur in degrees like, salivation or GSR. The amplitude *(A)* of a conditioned response varies directly with ${}_S\dot{\overline{E}}_R$.

Postulate 16: Incompatible Responses

When two or more incompatible responses are elicited in a situation, one with the greatest ${}_S\dot{\overline{E}}_R$ will occur.

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Changes in Hull's Theories From 1943 to 1952

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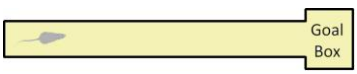
Changes after 1951

In 1943 version of his theory, Hull proposed that reinforcement affected learning. Experiments by Crespi (1942, 1944) and Zeeman (1949) suggested that performance, not learning was altered by the magnitude of reinforcement.



Running Speed (performance) in a straight runaway changes as a function of reinforcement, not learning in the animal.

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Performance (*K*)

Performance (*K*) drops dramatically when animals trained on a large reinforcement were switched to smaller reinforcement and vice versa. Thus momentary effective reaction potential required *K* as a product component to habit strength and drive.

$$_{S}\dot{E}_{R} = (_{S}H_{R} \ X \ D \ X \ K) - (I_{R} + {}_{S}I_{R}) - {}_{S}O_{R}$$

Hull concluded that organisms learn rapidly for a small or a large incentive, but *perform* differently for these incentives.

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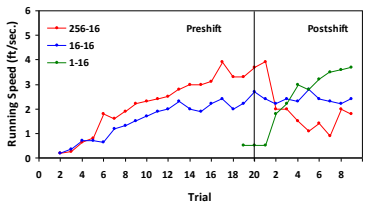
Crespi Effect

When rats were trained on a large reinforcement (256 pellets) and switched to smaller reinforcement (16 pellets) performance dropped, not learning, and vice versa. This was called Crespi Effect (1942).



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Stimulus Intensity Dynamism

Stimulus Intensity Dynamism *(V)* an intervening variable varied with the intensity of the external stimulus. When the intensity of an external stimulus increased, *V* increased, which increased the probability of a learned response.

$$ {}_S\dot{E}_R = ({}_SH_R \ X \ D \ X \ K \ X \ V) - (I_R + {}_SI_R)] - {}_SO_R $$

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Drive Stimulus Reduction (S_D)

Postulate 6 states that a biological deficit produces a drive *(D)* which is associated with drive stimuli. Reinforcement (food) to reduce a drive (hunger) would delay stimulus-response association. Hull changed that to drive stimulus reduction (S_D). Reinforcement reduced drive stimulus not the drive. Water quenched parched throat not thirst.

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Fractional Antedating Goal Response (r_G)

1. Fractional antedating goal responses (r_G) are small partial responses (salivating, chewing, etc.,) made by the organism prior to making the actual goal responses (eating, chewing, salivating).
2. r_G are not only responses but are also cues or stimuli (s_G) to subsequent responses. This is similar to Guthrie's movement-produced stimuli.

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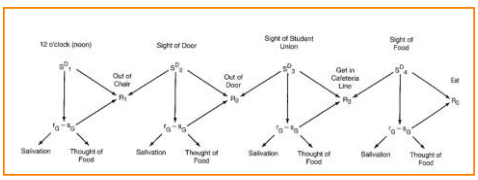
Fractional Antedating Goal Response (r_G)



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Habit Family Hierarchy

The organism can generate a number of possible overt responses s_G (habit family hierarchy) in any particular situation, and these serve as alternate ways of reaching a goal. The set of responses, that brings about reinforcement most rapidly and with the least amount of effort, will stick.

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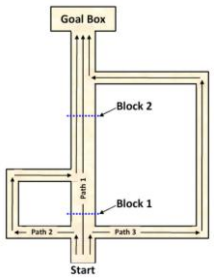
Habit Family Hierarchy

To test this idea Tolman and Gleitman (1949?) used a 3-path maze. Path 1 required least amount of effort bringing the reinforcement sooner, followed by path 2 and path 3. Their results confirmed habit family hierarchy.



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Evaluation

Contributions	Criticisms
Developed a systematic behavior theory.	Theory had little value beyond laboratory.
Popularized behaviorist approach.	Lack of internal inconsistency in the theory, e.g., the phenomenon of extinction can be explained by various postulates.
Precise definitions of variables and empirical verifications. e.g., definition of reinforcement.	Theory not revised in the face of contradictory data.

41

O. Hobart Mowrer

1. Born in Unionville, Missouri in 1907.
2. Did his PhD from John Hopkins University in 1932.
3. Mowrer became a colleague of Hull at Yale in 1940.

(1907-1982)

42

O. Hobart Mowrer

4. Mowrer went through a series of transitions in Hull's theory (1940-48).
5. From 1948 to the end of his professional carrier stayed at University of Illinois (Urbana).
6. Developed the two-process theory to explain avoidance learning.
7. Died 1982.

(1907-1982)

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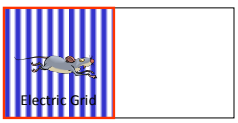
Escape Learning

In escape learning the organism confronts the aversive stimulus and acquires a response that removes it.



Shuttle Box

Electric Shock (Pain) → Response (Run away) → Reinforcement (Escape from pain)

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Avoidance Learning

In avoidance learning the organism acquires a response that prevents the aversive stimulation from ever happening. What is the reinforcement?

Shuttle Box

Signal (Light) → ~~Electric Shock (Pain)~~ → Response (Run away) → Reinforcement (Escape from pain?)

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Two-Process Theory

CS	US	UR
Light	Electric Shock	Fear/Pain

Classical conditioning: Sign Learning

CS	CR	US
Light	Run away	Escape Pain

Instrumental conditioning: Solution Learning

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Sign & Solution Learning

1. In avoidance learning, light (sign/warning) tells animal to avoid the shock because it is painful. Through classical conditioning the animal associates light with pain. Mowrer referred to this as sign learning.
2. Once the animal is warned about the shock and the resulting pain, it must perform a behavior (run away) to avoid the pain. Avoiding pain becomes negative reinforcement what Mowrer called solution learning.

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Emotions

1. In 1960, Mowrer went on to note that many emotions (other than fear) can be explained with his two-factor theory.
2. One can experience the emotion of hope if a bell (reinforcement) sounds just prior to food or of disappointment if the bell (reinforcement) sounds just prior to the removal of food.

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Reinforcers

1. Mowrer classified unconditioned stimuli into two kinds of reinforcers. Decremental reinforcers, were those that reduced a drive, e.g., food which reduces hunger.
2. And incremental reinforcers, increased a drive e.g., like shock which increases the need to avoid it.

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Mowrer's Theory

1. Eventually Mowrer considered all learning sign learning, because internal responses (proprioceptive) served as stimuli that gave a "sign" of what to expect and therefore solution learning was not needed.
2. Differing with Hull, Mowrer suggested that learning can occur both with drive induction (onset) and drive reduction (termination).

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Kenneth Wartinbee Spence

1. Born May 6, 1907 in Chicago, Illinois.
2. Student of Hull. Did his Ph.D. with him from Yale (1933).
3. Hull and Spence had tremendous influence on each other, therefore Hull learning theory is sometimes called Hull-Spence theory of learning.

(1907-1982)

51

Kenneth Wartinbee Spence

4. From 1930-1950 worked on discrimination learning in the chimpanzees and later in rats.
5. From 1950 onwards worked in classical conditioning of the eyeblink responses in humans.
6. Died on Jan. 12, 1967.

(1907-1982)

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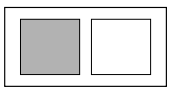
Discrimination Learning

When an animal (chimpanzee, rat or chicken) is presented with two stimuli and is reinforced for responding to one and not the other, discrimination learning takes place.



Gestalt psychologists (chiefly Kohler) had experimentally shown that animals learnt discrimination using a relational principle between stimuli.

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Discrimination Learning

1. Hull and other behaviorists faced strong criticism from these cognitive psychologists in explaining discrimination learning. Was discrimination learning between two stimuli based on relational principle or one specific stimulus?
2. It was Spence who defended Hull and experimentally rebutted Gestalt psychologists that discrimination learning took place in animals based on behavioral factors like habit strength, inhibition, and stimulus generalization.

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Latent Learning

Latent learning is implicit learning that takes place without reinforcement and remains dormant until reinforcement reveals it. Tolman and Hoznik (1930) did pioneering experiments in this area, and Spence and Lippitt (1940) replicated and confirmed these experiments later on.

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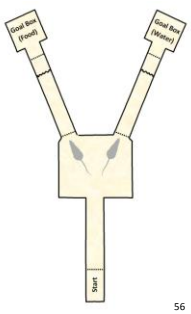
Latent Learning

Spence and Lippitt (1946) took sated and quenched rats and allowed them to explore a Y-maze with food and water in each arm. They were later divided in two groups and made them hungry and thirsty. Since the rats had latently learnt the maze hungry rats went to the arm with food (left) and thirsty rats to the arm with water (right).



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Arguments on Latent Learning

1. Hull suggested that removing the rats from the arm of the Y-maze was sufficient (though small), reinforcement to cause learning.
2. Spence disagreed and suggested that this type of learning occurred independent of reinforcement.
3. Animals learns a response by making it (contiguity: Guthrie, Aristotle) and making it many times (frequency: Aristotle).

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Latent Learning

For Hull, in the absence of drive (D) or incentive (K) a learnt response could not be emitted. Spence argued otherwise. If one has eaten frequently at a location at 6:00. Whenever at that location, at 6:00, will eat even though not hungry (D = 0) or not given an incentive (K = 0, latent learning). Spence changed Hull equation as follows:

$$ {}_S\dot{E}_R = {}_SH_R \ X \ (D \ + \ K) - (I_R + {}_SI_R)] - {}_SO_R $$

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Frustration-Competition Theory

1. Hull suggested when K= 0, reactive inhibition (I_R) and conditioned inhibition (${}_SI_R$) become larger and the response extinguished.
2. Spence argued when a regular reinforcer was removed and K equaled 0, the animal got frustrated for not receiving a reinforcer, and emitted responses incompatible with the learnt response which gets extinguished.

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Types of Frustration

1. Primary Frustration: Not finding the reinforcement (food) in the goal box.
2. Fractional anticipatory frustration reaction (r_F) A frustration caused by anticipating (Tolman's *beliefs*) no reinforcement in the goal box. All such responses (r_F) become stimuli (s_F) for resisting the goal box.

60

Abraham Amsel

1. Born 1922 Montreal, Canada.
2. Worked with Spence and Hull.
3. Wrote *Behaviorism, neobehaviorism and cognitivism in learning theory (1989).*

(1922-2006)

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Abraham Amsel

4. Agreed with frustration-competition theory. *Frustration theory : An analysis of dispositional learning and memory* (1992).
5. Ashbel Smith Professor Emeritus at University of Texas Austin.
6. Died in Sep. 6, 2006.

(1922-2006)

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Frustration Experiment

To test frustration hypothesis, Amsel and Roussel, (1952) reinforced animals at the ends of two connected runways continuously. They then reinforced animals in runway 1, 50% of the time, and in runway 2, 100% of the time. Animals ran faster in runway 2 due to frustration for not finding reinforcement in runway 1.

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Properties of Frustration

1. Primary frustration (R_F): Unlearnt drive-like state caused by absence of reinforcement.
2. Internal Stimulation (S_F): Primary frustration produces its own drive stimuli, also called frustration drive stimulus.
3. Environmental Stimuli: trigger responses causing primary frustration in the absence of reinforcement.
4. Internal Feedback Stimuli: Secondary reinforcers that are actually responses, turned stimuli.

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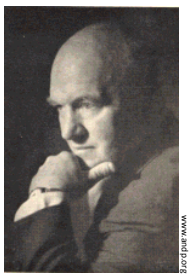
Neal Miller

1. Born in 1902 in Milwaukee, Wisconsin.
2. Miller was Hull's student and remained at Yale for 30 years (1936-66). Combined Hull and Freudian approaches.
3. Spent 15 years at Rockefeller University (1966-1981) before becoming Professor Emeritus at Rockefeller.



(1902-2002)

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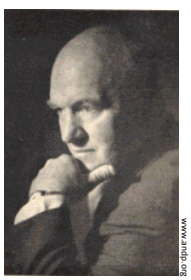
Neal Miller

4. He investigated learned changes in visceral responding and the application of biofeedback on behavioral medicine.
5. James Rowland Angell Professor of Psychology. President of the APA (1960-61) and SFN (1971-72).
6. Died 2002.



(1902-2002)

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Behavioral Neuroscience

Visceral Conditioning	Biofeedback
Miller showed that autonomic responses like heart rate, blood pressure and skin temperature could be instrumentally conditioned.	Many experiments led to practical uses of biofeedback to behavioral medicine and neuroscience), including controlling high blood pressure, migraines, and epilepsy etc.

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Questions

20. Based on the reinforcements (N, see data below) calculate habit strength ($_SH_R$), draw a graph and explain how magnitude of reinforcement increases learning?
21. Describe two-factor theory that Mowrer developed to explain avoidance conditioning. In your answer be sure to explain sign and solution learning.
22. Explain how extinction of a response takes place in Hull, Spence and Amsel theories? Make sure you explain the differences.

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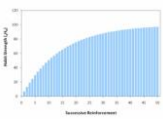
Data for Q 20

Reinforcement (N)	Habit Strength	Reinforcement (N)	Habit Strength
0		26	
2		28	
4		30	
6		32	
8		34	
10		36	
12		38	
14		40	
16		42	
18		44	
20		46	
22		48	
24		50	

To calculate habit strength ($_SH_R$) use formula given in postulate 4. Draw a graph like the one shown below and answer Q20.



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